WHAT IS CLAIMED IS:

1. A cylinder-by-cylinder intake air quantity detecting apparatus for an internal combustion engine having a plurality of cylinders, the cylinder-by-cylinder intake air quantity detecting apparatus comprising:

a detecting unit including at least one of an airflow meter for detecting an intake air quantity flowing in an intake pipe, a pressure sensor for detecting pressure in the intake pipe, and an in-cylinder pressure sensor for detecting in-cylinder pressure;

a cylinder-to-cylinder variation learning unit for calculating the rate of cylinder-to-cylinder variations in intake air quantity or the cylinder-by-cylinder intake air quantities based on an output from the detecting unit and for learning the calculated value as a learning value of cylinder-to-cylinder variations in the operating range in which a condition to execute variation learning is met; and

a cylinder-to-cylinder variation estimating unit for estimating the rate of cylinder-to-cylinder variations in intake air quantity or the cylinder-by-cylinder intake air quantities according to a current operating range using the learning value of cylinder-to-cylinder variations in the operating range in which the condition to execute variation learning is not met.

2. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 1, wherein the condition to execute variation learning is met during at least

one of a fuel-cut operation and a cranking operation.

3. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 1, wherein the condition to execute variation learning is met during an operation in reduced speed.

4. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 1, wherein the condition to execute variation learning is met when a number of an engine revolution is less than a predetermined number and the intake air quantity is more than a predetermined quantity.

5. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 1, further comprising:

an intake valve provided on an upstream side of the cylinder for introducing an air-fuel mixture into the cylinder;

an exhaust valve provided on a downstream side of the cylinder for exhausting combustion gas from the cylinder; and

a throttle valve provided in the intake pipe for controlling intake air quantity flowing in the intake pipe,

wherein the cylinder-to-cylinder variation learning unit changes the operating conditions of at least one of the intake valve, the exhaust valve, and the throttle valve into a predetermined operating condition during the learning value of the cylinder-to-cylinder variations is learned in the

operating range in which the condition to execute variation learning is met.

6. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 5, wherein the cylinder-to-cylinder variation learning unit changes the opening of the throttle valve into a fully opened state or to an opening degree in which the intake pipe pressure is in the vicinity of ambient pressure so as to learn the learning value of the cylinder-to-cylinder variation in the operating range in which the condition to execute variation learning is met.

7. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 5, wherein the cylinder-to-cylinder variation learning unit changes the lift amount of the intake valve to at least one of a predetermined lift amount or less and a minimum value, to learn the learning value of cylinder-to-cylinder variation in the operating range in which the condition to execute variation learning is met.

8. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 5, wherein the cylinder-to-cylinder variation learning unit changes the timings of the intake and the exhaust valves so as to eliminate valve overlap between the intake valve and the exhaust valve while defining an opening period of the intake valve at a range between a top dead center of the internal combustion engine and a bottom dead center of the internal

combustion engine to learn the learning value of cylinder-to-cylinder variation in the operating range in which the condition to execute variation learning is met.

9. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 5, further comprising:

a variable intake valve mechanism provided with the intake valve for varying a lift amount of the intake valve; and

a unit for controlling the variable intake valve mechanism so as to control the intake air quantity.

10. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 9, wherein the cylinder-to-cylinder variation estimating unit estimates the rate of cylinder-to-cylinder variations in intake air quantities or the cylinder-by-cylinder intake air quantity corresponding to a current lift amount of the intake valve, using the learning value of cylinder-to-cylinder variations leaned by the cylinder-to-cylinder variation leaning unit, the lift amount of the intake valve when the learning value of cylinder-to-cylinder variations is learned, and the current lift amount of the intake valve.

11. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 9, further comprising:

a unit for prohibiting the variable intake valve mechanism from controlling intake air quantity, during a

period in which the learning value of cylinder-to-cylinder variations is learned by the cylinder-to-cylinder variation learning unit, wherein

the intake air quantity is controlled by the throttle valve during a period in which the learning value of cylinder-to-cylinder variations is learned by the cylinder-to-cylinder variation learning unit, and

the intake air quantity is controlled by the variable intake valve mechanism after completion of leaning of the learning value of cylinder-to-cylinder variations.

12. A cylinder-by-cylinder intake air quantity detecting apparatus for an internal combustion engine having a plurality of cylinders, the cylinder-by-cylinder intake air quantity detecting apparatus comprising:

a detecting unit including at least one of an airflow meter for detecting an intake air quantity flowing in an intake pipe, a pressure sensor for detecting intake pipe pressure in the intake pipe, and an in-cylinder pressure sensor for detecting in-cylinder pressure;

a cylinder-to-cylinder variation learning unit for calculating the rate of cylinder-to-cylinder variations in intake air quantity or the cylinder-by-cylinder intake air quantities and learning the calculated value as a learning value of cylinder-to-cylinder variation based on the output from the detecting unit; and

a unit for prohibiting the variable intake valve mechanism from controlling intake air quantity, during a

period in which the learning value of cylinder-to-cylinder variations is learned by the cylinder-to-cylinder variation learning unit, wherein

the intake air quantity is controlled by the throttle valve during a period in which the learning value of cylinder-to-cylinder variations is learned by the cylinder-to-cylinder variation learning unit, and

the intake air quantity is controlled by the variable intake valve mechanism after completion of leaning of the learning value of cylinder-to-cylinder variations.

13. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 1, wherein the detecting unit detects the intake pipe pressure, and the cylinder-to-cylinder variation learning unit learns the learning value of cylinder-to-cylinder variations based on a minimum value of the intake pipe pressure.

14. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 1, wherein the detecting unit detects the in-cylinder pressure, and the cylinder-to-cylinder variation learning unit learns the learning value of cylinder-to-cylinder variations based on a maximum value of the in-cylinder pressure.

15. A cylinder-by-cylinder intake air quantity detecting apparatus for an internal combustion engine having a plurality of cylinders, the cylinder-by-cylinder intake air

quantity detecting apparatus comprising:

a detecting unit including at least one of an airflow meter for detecting an intake air quantity flowing in an intake pipe, a pressure sensor for detecting intake pipe pressure in the intake pipe, and an in-cylinder pressure sensor for detecting in-cylinder pressure;

an area calculating unit for calculating the area of the intake air quantity of the output waveform from the detecting unit for a predetermined period for one of every intake stroke and every compression stroke of each cylinder;

a cylinder-to-cylinder intake air quantity variations calculating unit for calculating the rate of cylinder-to-cylinder variations in intake air quantity or the cylinder-by-cylinder intake air quantities according to the area of the intake air quantity for the predetermined period of each cylinder.

16. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 15, wherein

the detecting unit detects at least one of the intake air quantity and the intake pipe pressure, and

the area calculating unit sets the predetermined period to a period in which the intake air quantity is hardly subjected to an influence of a reflected wave from an intake air pulsation or an air intake interference of other cylinders.

17. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 16, wherein the area

calculating unit sets the predetermined period to at least one of a period including a maximum value of the intake air quantity and a period including the minimum value of the intake pipe pressure.

18. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 16, wherein the area calculating unit sets the predetermined period to a valve-opening period of the intake valve.

19. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 16, wherein the detecting unit detects the intake air quantity, and the area calculating unit sets the predetermined period taking into account a detection delay of the detecting unit.

20. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 16, wherein the detecting unit detects the intake air quantity, and the area calculating unit sets the predetermined period to at least one of a period in which the intake air quantity is equal to or greater than an average value and a period in which the intake pipe pressure is less than an average value.

21. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 16, wherein the detecting unit detects the intake pipe pressure, and the area calculating unit calculates the area of the intake air

quantity and converts the intake pipe pressure detected by the detecting unit to the intake air quantity.

22. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 16, wherein the detecting unit detects the intake pipe pressure, and the area calculating unit sets the predetermined period taking into account a detection delay of the detecting unit.

23. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 16, wherein the detecting unit detects the intake pipe pressure, and the area calculating unit sets the predetermined period to a period in which an intake air quantity converted from the intake pipe pressure becomes larger than an average value of the intake air quantity converted from the intake pipe pressure.

24. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 15, wherein the detecting unit detects the in-cylinder pressure, and the area calculating unit sets the predetermined period to the timing before ignition.

25. A cylinder-by-cylinder intake air quantity detecting apparatus according to Claim 24, wherein the area calculating unit sets the predetermined period to a period including a maximum value of the in-cylinder pressure during one of a fuel-cut operation and a cranking operation.